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A Study of the Influence  
of the Amount of Organic  
Matter in Soils upon their  
Water Holding Power

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A STUDY OF THE INFLUENCE OF  
THE AMOUNT OF ORGANIC MATTER  
IN SOILS UPON THEIR WATER  
HOLDING POWER

BY

JOHN WALLACE MCLANE

THESIS FOR THE DEGREE OF BACHELOR OF SCIENCE

IN THE

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1901



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May 31,

1906

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

John Wallace McLane

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in Soils upon their Water Holding Power.

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science.

*H. E. Mead, Instr. in Soil Physics.*  
*Cecil G. Hopkins*  
*Agronomy.*  
HEAD OF DEPARTMENT OF





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## Introduction.

The necessity of moisture for the growth and development of plants has been known from the very earliest times. The harvest was recognized as made possible by the occurrence of timely showers; but it is a question whether the relation of soil to the supply of moisture for the plant was appreciated or understood.

It was not until the revival of Agricultural investigation, in the early part of the nineteenth century, that the influence of the physical properties of the soil upon its water content began to be studied, in a scientific manner at least. That a fairly comprehensive view of the subject was taken at that time is shown by the following statement made by Sir Humphry Davy: "The power of soils to absorb water from the air is much connected with fertility. When this power is great, the plant is supplied with water in dry seasons, and the effect of evaporation in the day is counteracted by the absorption of aqueous vapor from the atmosphere, by the interior parts of the soil during the day, and by both the exterior and the interior during the night."

And again, in regard to the food of plants, he says: "Water and the decomposing animal and vegetable matter existing in the soil constitute the true nourishment of plants, and as the earthy parts of the soil are useful in retaining water, so as to supply it in the proper



proportions to the roots of the vegetables, so they are likewise efficacious in producing the proper distribution of the animal or vegetable matter; when equally mixed with it, they prevent it from decomposing too rapidly, and by their means the soluble parts are supplied in proper proportions".

also

The above quotation illustrates the incompleteness of the knowledge of that time, in regard to the true nature of plant food, and it was not until 1840 that Liebig advanced his mineral theory of plant growth upon which our modern theory and practice of fertilization have been based. Following Liebig, the investigations of soils have been largely of a chemical nature, until in 1875 when the insufficiency of such investigation was pointed out. And while chemical investigation of soils was continued, physical investigation has been given more and more prominence.

The Department of Agriculture of the United States, together with various Experiment Stations, <sup>have</sup> ~~has~~ taken up the work of determining the physical properties of soils and their relation to the various crops, and much valuable data has been collected, showing that of all the physical properties of soils, the most important in relation to crop production is, undoubtedly, the capacity of the soils for furnishing water to the plant.

#### Object of Investigation.

The present investigation has been conducted with the view of obtaining data, such as could be secured by field observations, indicating the physical conditions of certain soils containing varying amounts





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of organic matter, especial attention being given to their water holding capacity. The effect of the physical conditions of the soils upon their temperature was also contemplated.

While the above named objects were the primary ones in the investigation, a knowledge of the instruments and methods used in such investigations was considered important and due attention was given to the study of the principles upon which they are based.

#### Plan of Work.

The soils experimented upon were those of four plats upon the experimental farm of the University of Illinois. The first ~~one~~ that of the corn exhaustion plat which will be referred to as the "Corn" plat is one-half acre in extent and has been cropped to corn continuously for twenty-five years. The grain and stalks were removed and no fertilizers of any kind added.

The second was the next plat south of the "Corn" plat and will be called the "Corn and Oats" plat. It is also a half acre in extent and has been devoted to the raising of the two indicated crops alternately for the same period of twenty-five years. The growth of grain and stalks were removed as in the foregoing and no fertilizer added.

Adjoining the "Corn and Oats" plat on the south is another half-acre tract, which will be referred to as the "Rotation" plat, upon which an attempt has been made to grow clover as one number a rotation with corn and oats as the other two.

An effort to secure a portion of soil approaching, as nearly as possible, that of the original prairie resulted in the plowing up a



strip of the blue grass sod which formed the border along the east side of the above mentioned plats. ( See plan of field )

As a result of the different management each plat has received, they differ as to their content of organic matter, as follows:  
"Corn" plat, 6.61%; "Corn and Oats" plat, 7.66%; "Rotation" plat, 7.75%; "Border" plat, 3.77%. These are percentages found in a composite sample from the first foot in each plat. The composite sample being made up <sup>of</sup> soil taken at each station. During the experiment all the plats have been similarly treated. They were plowed late in the fall of 1900, disced on the 19th. day of May, and disced and <sup>the corn</sup> planted on the 20th. of the same month.

It will be seen by reference to the plan of the experimental field that three stations have been established in each plat, "A", "B", and "C" respectively, beginning at the west in all except the border plat where "A" occupies the southern position, the others following in order. The stations are placed on the middle line of the width of the plats and at varying distances in the other direction.

In all there are twelve stations and at each station three depths were studied; The first at eight inches, the second at eighteen inches the third at twenty-eight inches. These are designated as "First" foot, "Second" foot, and "Third" foot in the accompanying diagrams.

Temperature readings were made at one station, "B", on each plat but this included the three depths at these stations.

These four plats under consideration are similarly located as to exposure and drainage and it is reasonable to suppose that they <sup>were</sup> originally alike in all other respects.





## Description of Apparatus

The method employed in the determination of soil moisture is the one used by the Division of Soils, Department of Agriculture. It has been developed by this branch of the public service and is regarded as highly satisfactory. It is known as the Electrical Method of Moisture determination and is "based upon the principle that the resistance offered to the passage of an electrical current from one electrode to another buried in the soil varies with the amount of water present in the soil". The Hygrometer, the instrument used for measuring the resistance was at hand but it was necessary to construct the remainder of the apparatus, consisting of soil electrodes and compensating cells. This with the installing, the location of faults and the correction of the same, and finally the reading of the instrument from day to day occupied the largest part of the time spent in this investigation. As a guide for this work reference was made to Bulletin No. 15, of the Division of Soils. This Bulletin contains a full and detailed description of the apparatus used in this determination, together with that used in the determination of temperature and also the soluble salts content of the soil. The Bulletin was prepared by Lyman J. Briggs, Assistant Chief of the Division who has done much toward the development of these methods. In view of the fact that so reliable and clear a statement is readily obtainable any further description is deemed unnecessary.

In addition to the determination of moisture an attempt was made to construct the apparatus for the determination of soil temperature which resulted in the possession of apparatus for one fourth the number



of determinations made for soil moisture. In way of explanation of the temperature apparatus, I quote from the above mentioned Bulletin, "The change in the electrical resistance of metals with temperature enables us to employ this property as a thermometer by measuring variations in the electrical resistance of a suitable coil of wire located at the desired point. A convenient instrument for this purpose has been devised and lends itself readily to the measurement of temperatures in inaccessible places, such as the temperature of the soil at various depths \* \* \* and, in fact, at any point where it is desired to determine the temperature and where it is inconvenient to use mercurial thermometers"

#### Installing of Apparatus

The carbon electrodes and compensating temperature cells for the determination of soil moisture of the three depths were arranged with the thought in mind of placing them as near as possible in a common vertical line and also that the arrangement should be convenient. It seemed impossible to place them in the same vertical line with one another as that would interfere with the raising or lowering of the plunger of the compensating cell which is necessary in the adjustment of the apparatus. Another difficulty in the way of this arrangement would be a less favorable condition for the securing the perfect contact between the carbons and the soil as the latter under these circumstances would be less compact. The following plan was employed. An equilateral triangle whose sides were about three feet was drawn upon the surface of the ground and the carbons and compensating cells were arranged along its sides at the proper depths. The lead wires from the several



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depths, collected in groups and wrapped by a wire the number of turns of which indicated their depth, were brought to the surface at a central point. It might be well to state that the carbon electrodes of each determination were placed two feet apart. The separate wires of the groups were distinguished by the number of knots tied in the end of the wire; the wire from the compensating cell having one knot, that from the soil electrode to which the wire from the compensating cell was connected was marked by two knots, while the other wire was unmarked. All wires projected some six inches above the surface of the soil thus affording opportunity for an easy connection with the lead wires from the Hygrometer. The connections were made by means of an ordinary electric wire coupling, to one end of which was connected the instrument wire and in the other end was secured several spring wires, the contact being made by pressing the end of the soil wire between the spring wires of the coupling. This connection was quickly made and quite satisfactory.

In the case of the temperature determination cells they were placed in a vertical line in the soil. The lead wires were brought to the surface at a point as near the moisture determination wires as possible, thus presenting a minimum area of soil which could<sup>not</sup> be cultivated.

### Field Notes

The following diagrams represent in a graphic way the water content of the several depths at the twelve different stations, with the exception of "A" of "Border" plot, which ceased reading during the early part of the investigation and with the limit of time at command it re-





ained uncorrected. Another general observation is that though an attempt was made to avoid mistakes they in all probability occurred which will account for some of the results which can not otherwise be explained. In regard to the sudden and decided fall in the water content, especially noticed in the corn plot, about the eighteenth of May is explained by the fact that upon that day the wires were uncovered to enable the securing of a more permanent connection, by means of soldering, between the wire from the compensating cell and that of the carbon electrode. During this operation the soil of each station was similarly treated and it is of interest to note the very rapid loss of water from the "Corn" plot while that of the "Border" plot was little effected.

In standardizing the moisture determination apparatus, the samples of soils used were dried at a temperature of 100 to 110 degrees C. to constant weight. The percentage of moisture was computed upon the basis of water-free soil.

It was observed that the time of germination of the grain planted in the "Border" plot was less, by two days, than that of any of the other plots. And as the germination is mainly affected by the physical condition of the soil the above observation has an important bearing on the present investigation.

### Conclusions

The results of but one month's readings are far from conclusive, yet some important facts seem to be clearly indicated by the data collected.

The moisture content of the first foot of the "Border" plot does



not appear to have been much effect<sup>e</sup>d by the rain fall, while a marked increase <sup>in the</sup> moisture content of the second and third feet is noted after each rain. This would seem to indicate that the soil of the "Border" plat retained approximately a constant amount of water and allowed whatever of excess there might be to pass readily into the soil below. It is also observed that the moisture is not reduced to any great extent even when the humidity of the air is lowered and the temperature raised, which fact would go to show the power of the soil to retain moisture under varying conditions.

In the "Corn" plat the first foot contained less moisture than the second and third, which indicates that it does not have the power of retaining the moisture, but loses it quickly through evaporation. This is further shown by the fact that the moisture content of the soil of the first foot quickly ran up after each rain, while those of the second and third feet were but slightly influenced. The water in this case was evidently held for a short time by the top soil, the length of time clearly depending in a measure upon the humidity of the air.

The most definite conclusion that can be drawn from the results of the investigation is that the soil of the "Border" plat <sup>has</sup> the greatest water holding power of the soil of any of the plats investigated, and the soil of the "Corn" plat has the least water holding power of any of them. And as these two plats contain, also, the greatest amount and the least amount of organic matter, respectively, it seems reasonable to conclude that the water holding power of soil other conditions being the same, is in direct proportion to the amount of organic matter which it contains.



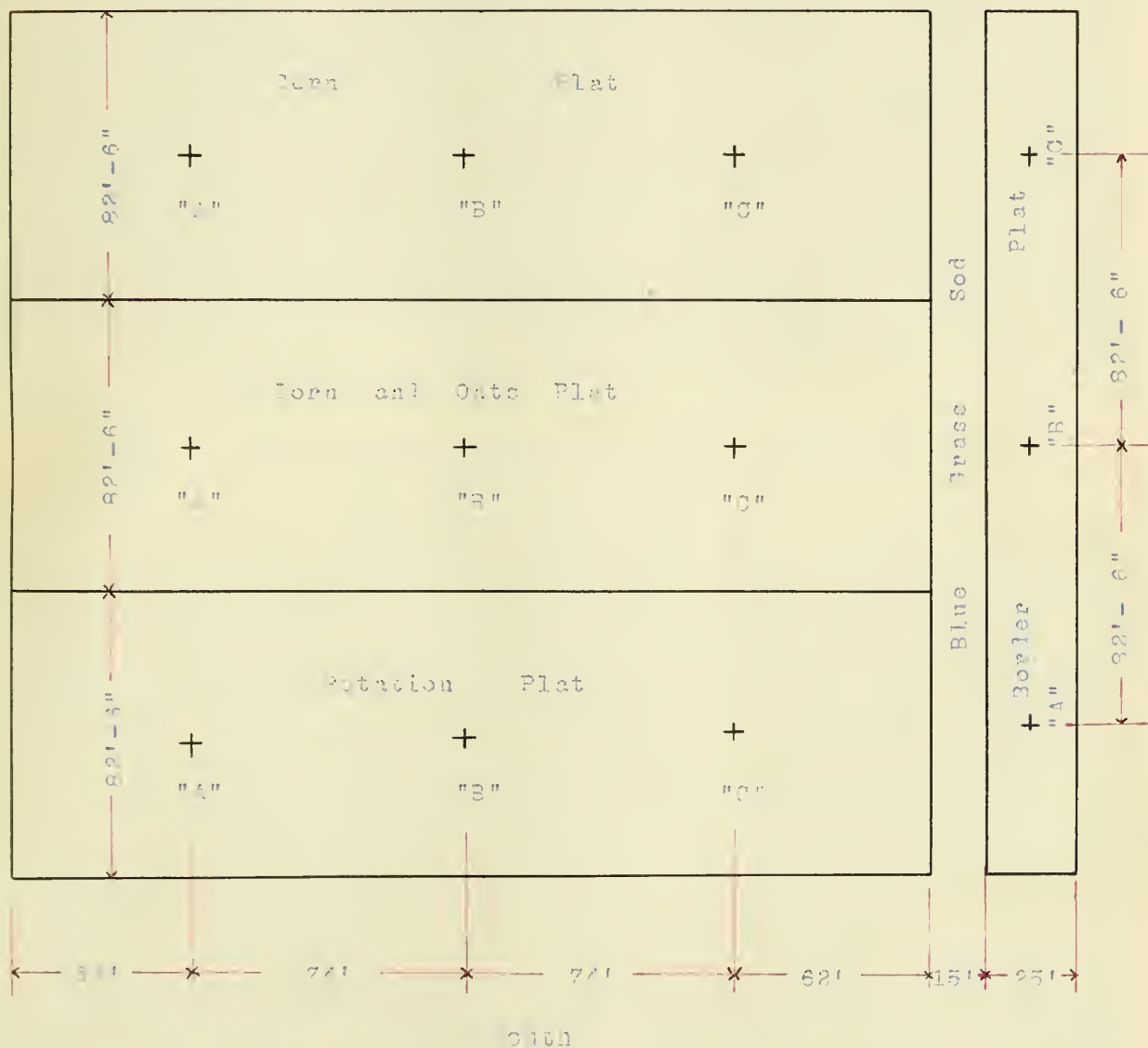


# PLAN OF FIELD

\* \* \*

showing size and relative location of the plots  
together with the position of each station.

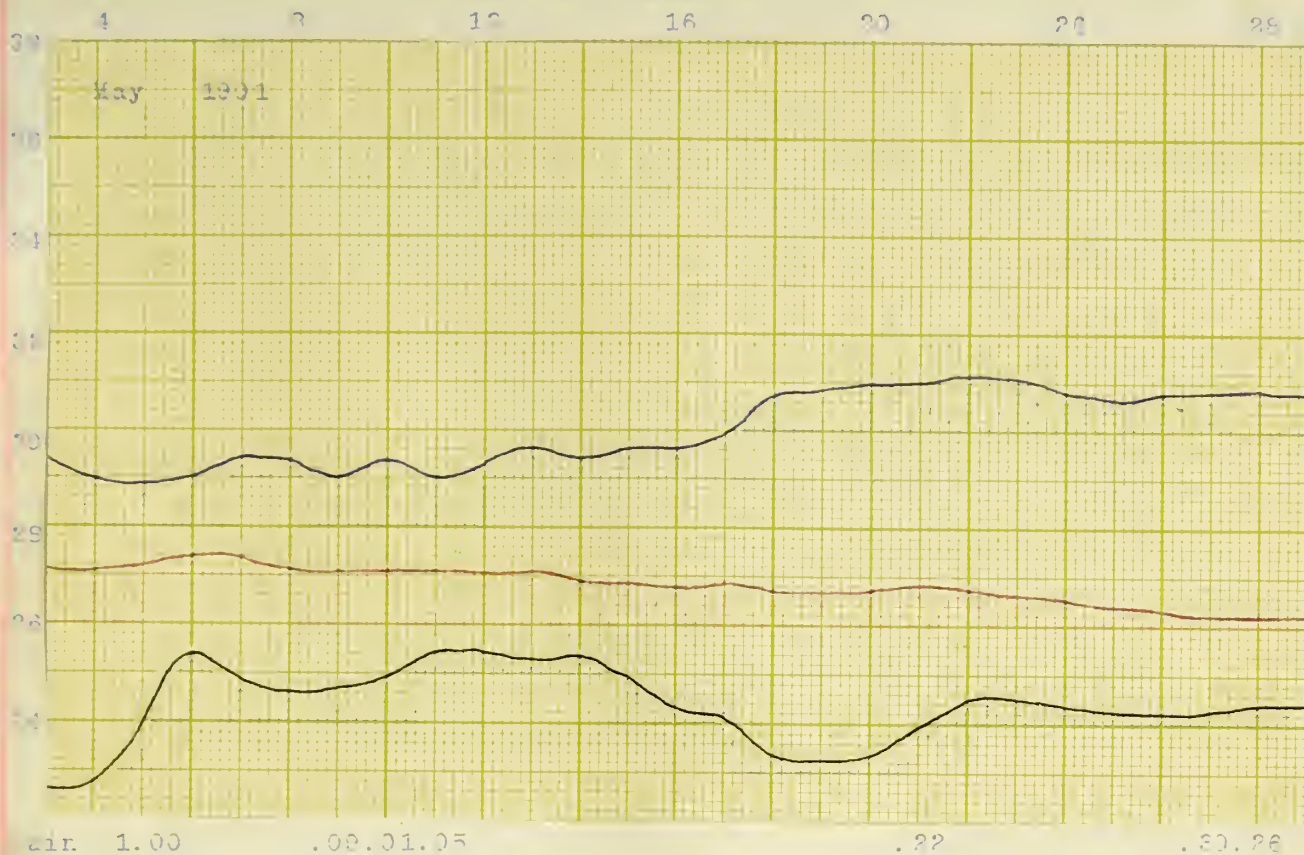
North



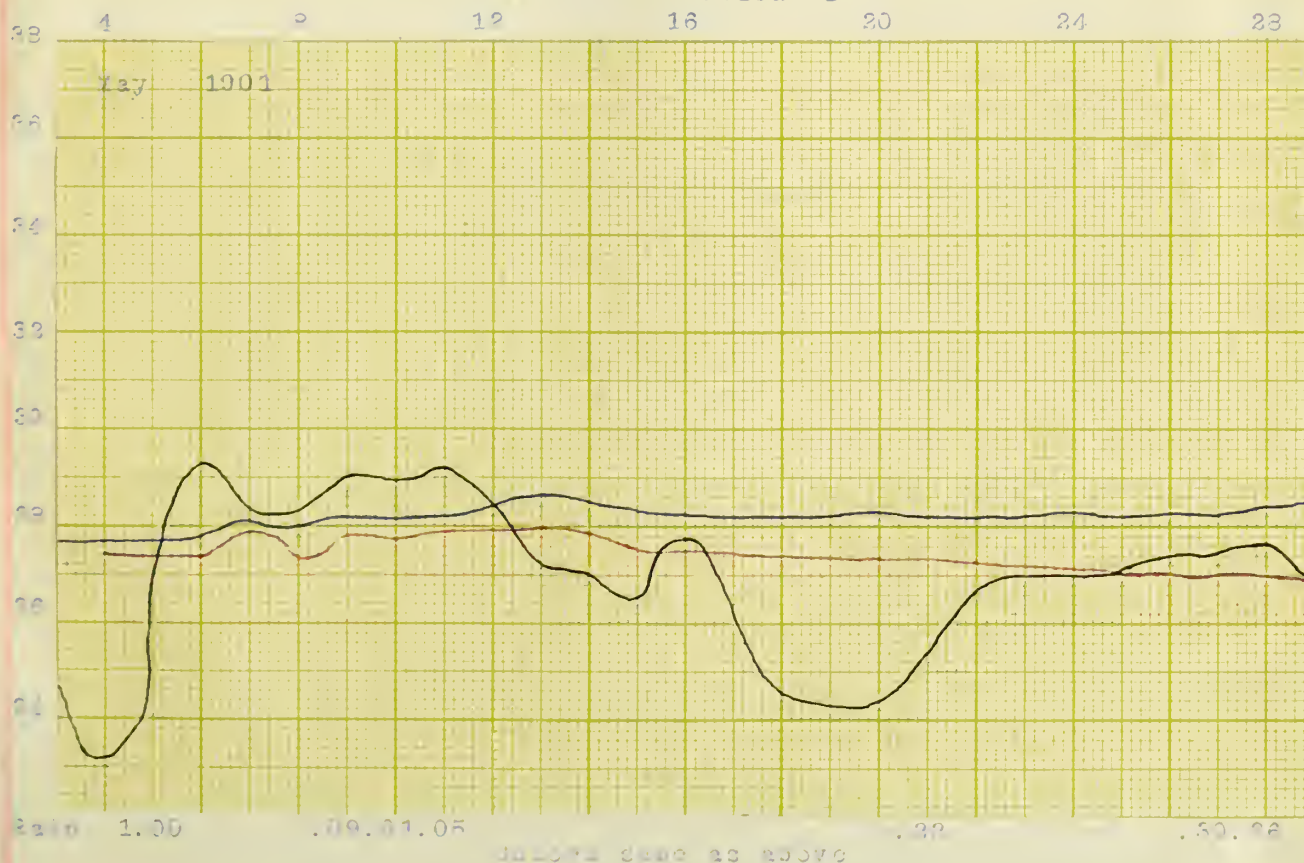
The plots are located in the northeast quarter of the  
Experimentation Field lying immediately south of the Astronom-  
ical Observatory on the South Campus.



# Corn Plat - Station "A"



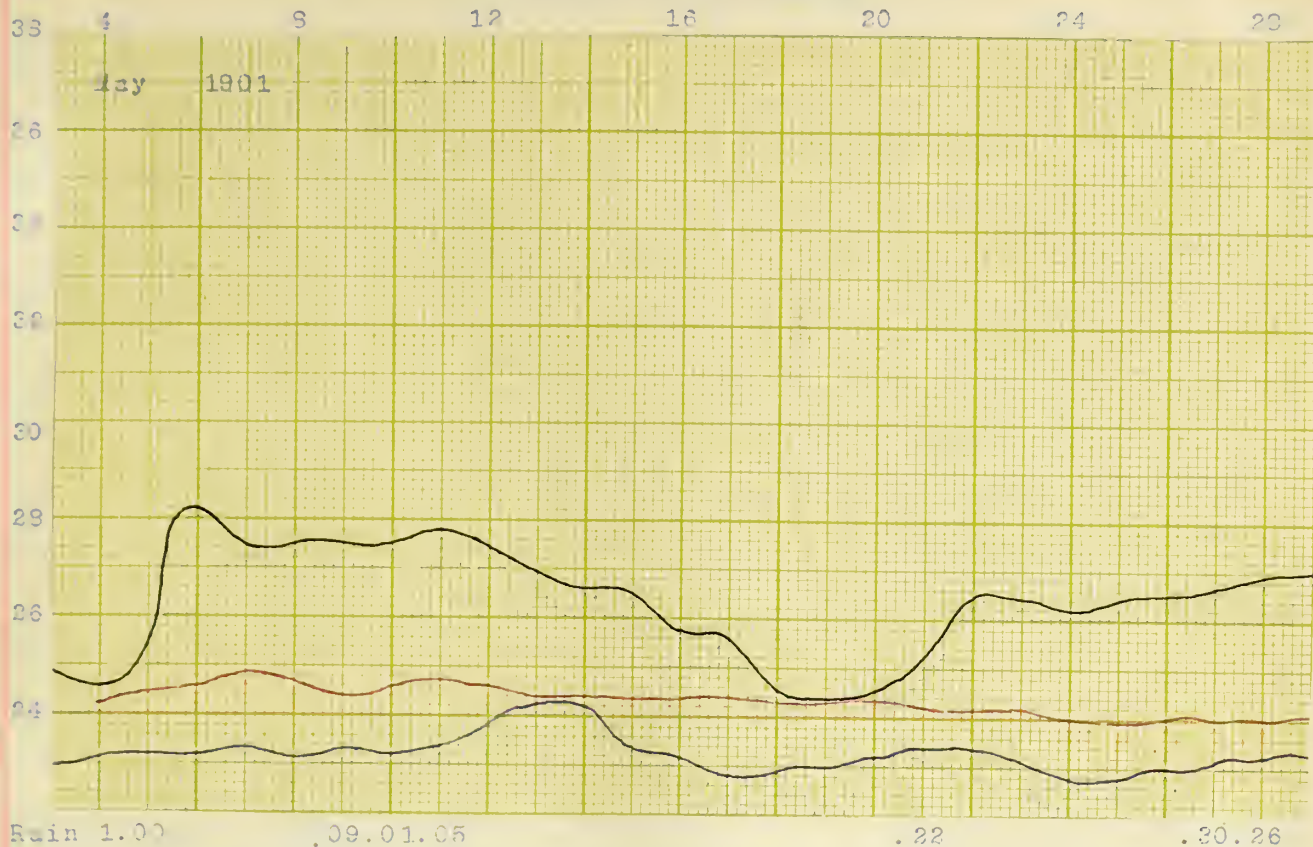
# Corn Plat - Station "B"







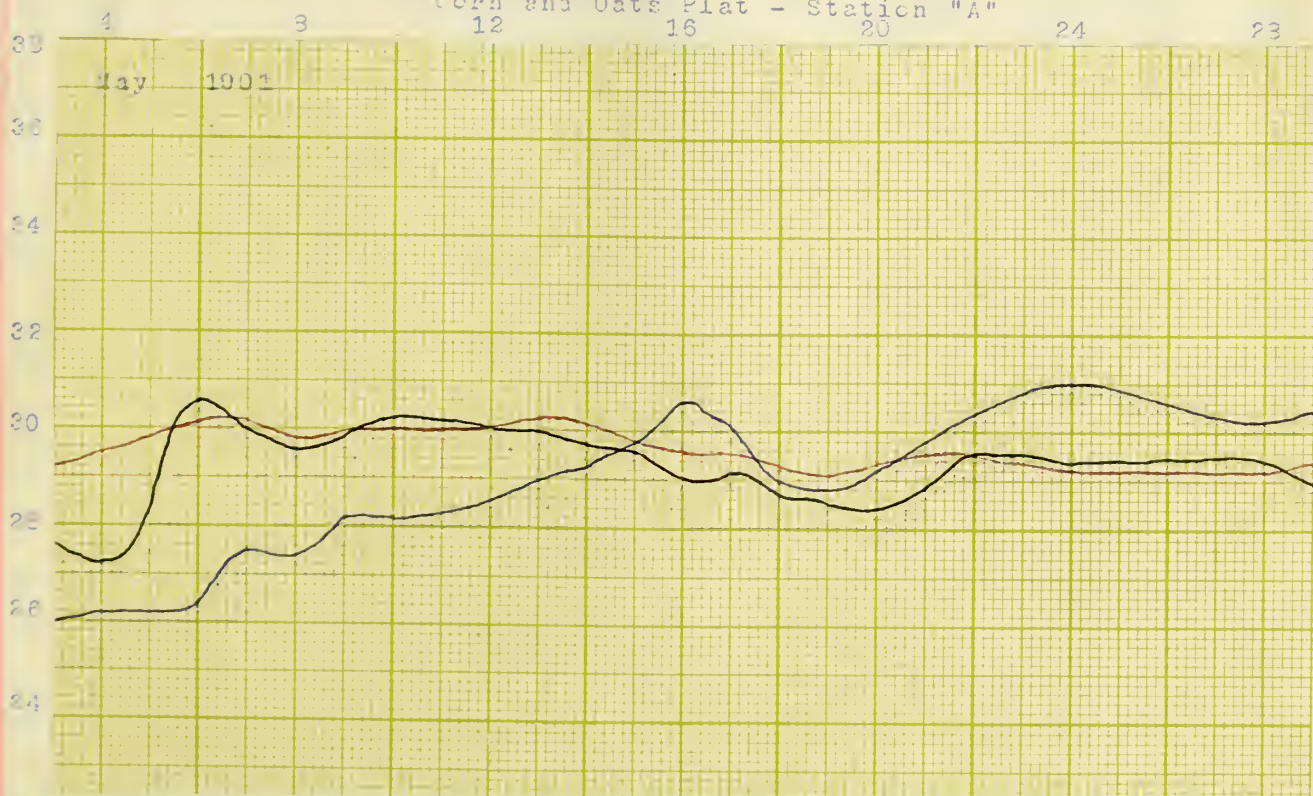
Corn Plat - Station "C"



Rain 1.00 .09.01.05 .22 .30.26  
First foot - Black Second foot - Red Third foot - Blue

\*\*\*\*\*

Corn and Oats Plat - Station "A"

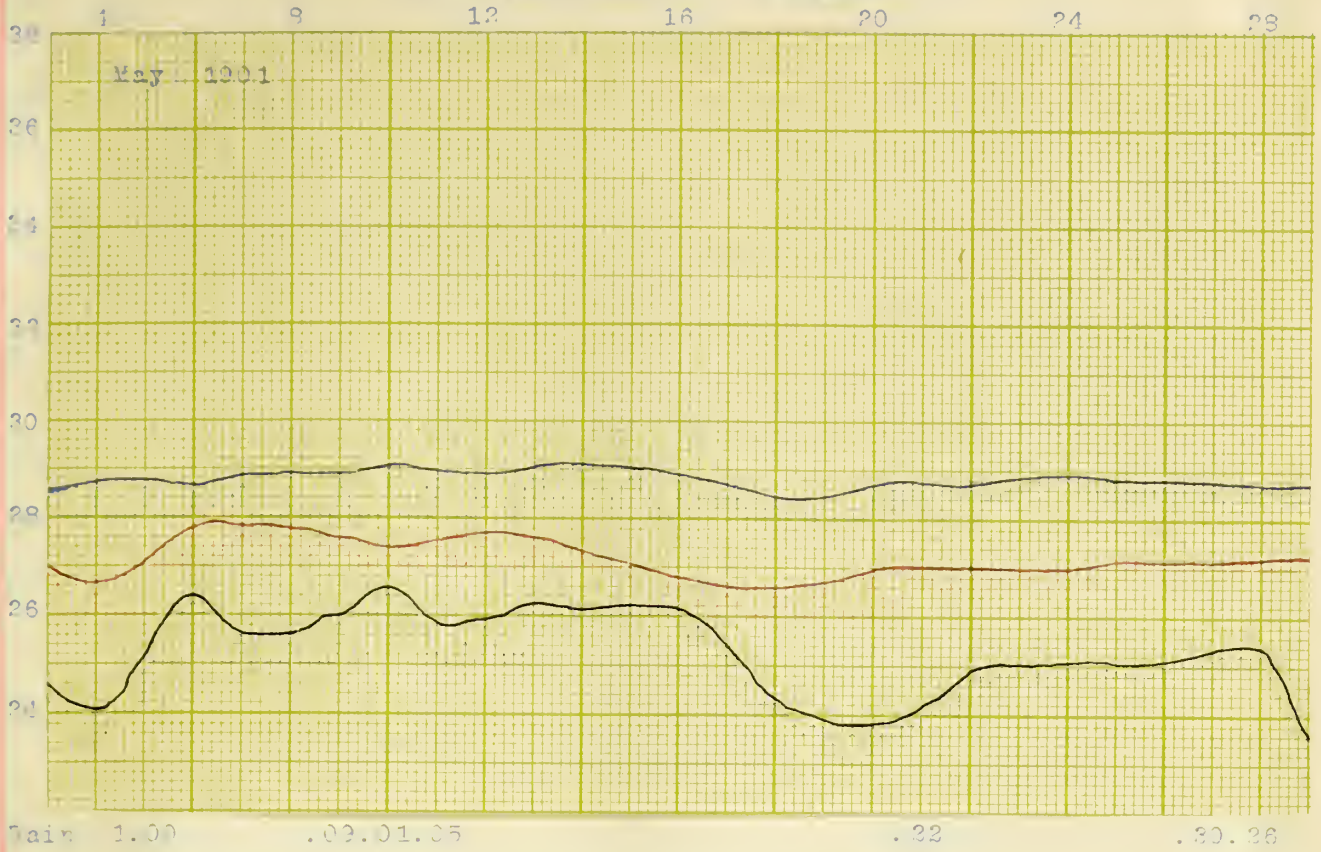


Rain 1.00 .09.01.05 .22 .30.26

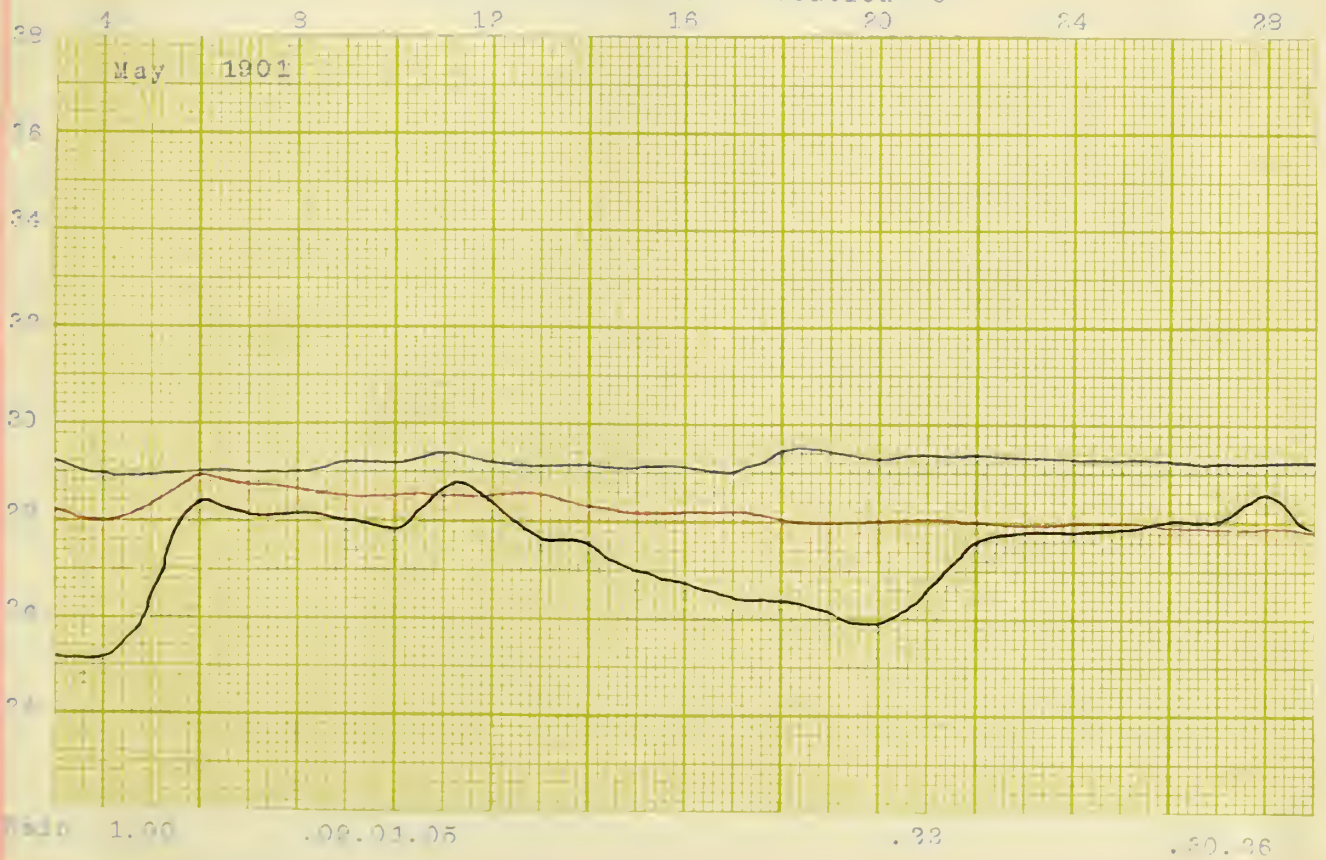




# Corn and Oats Plat - Station "B"



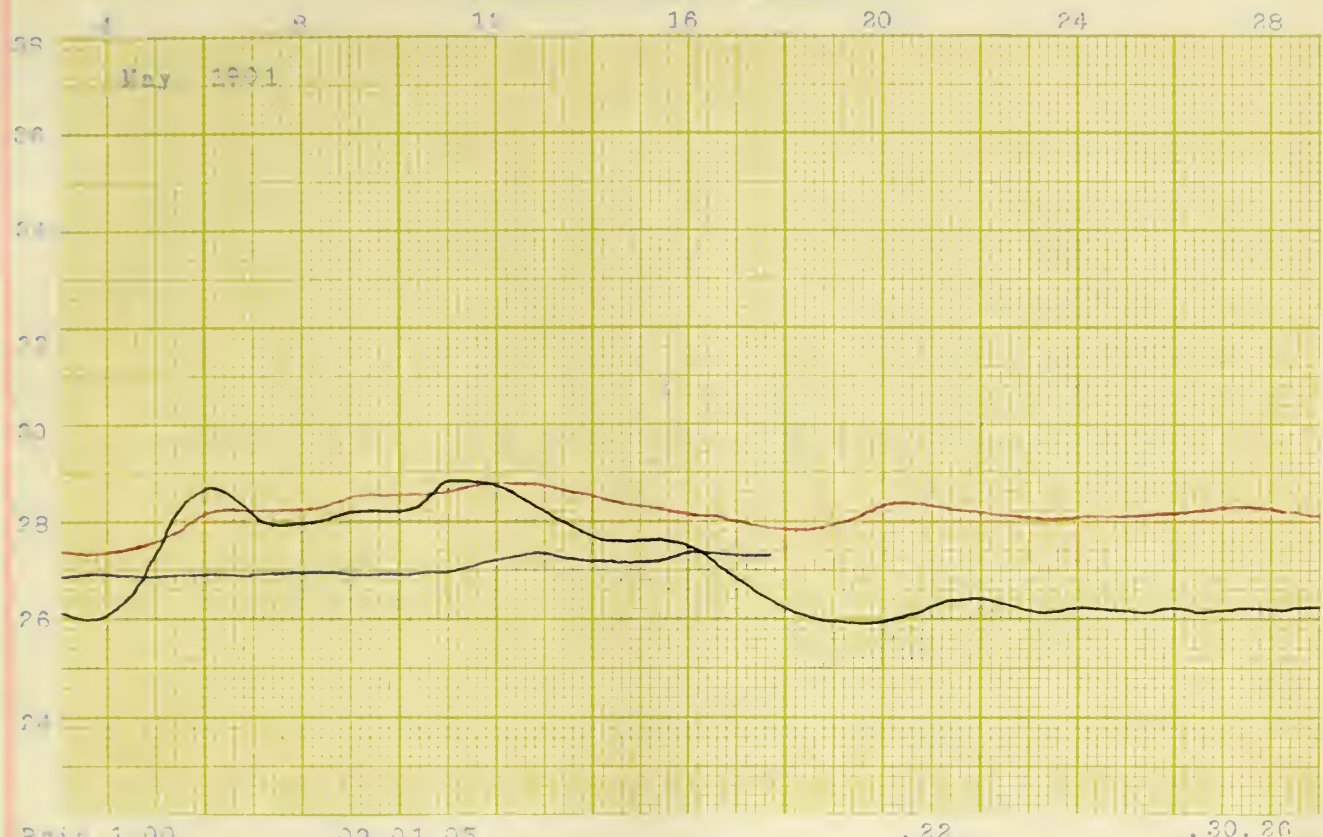
# Corn and Oats Plat - Station "C"







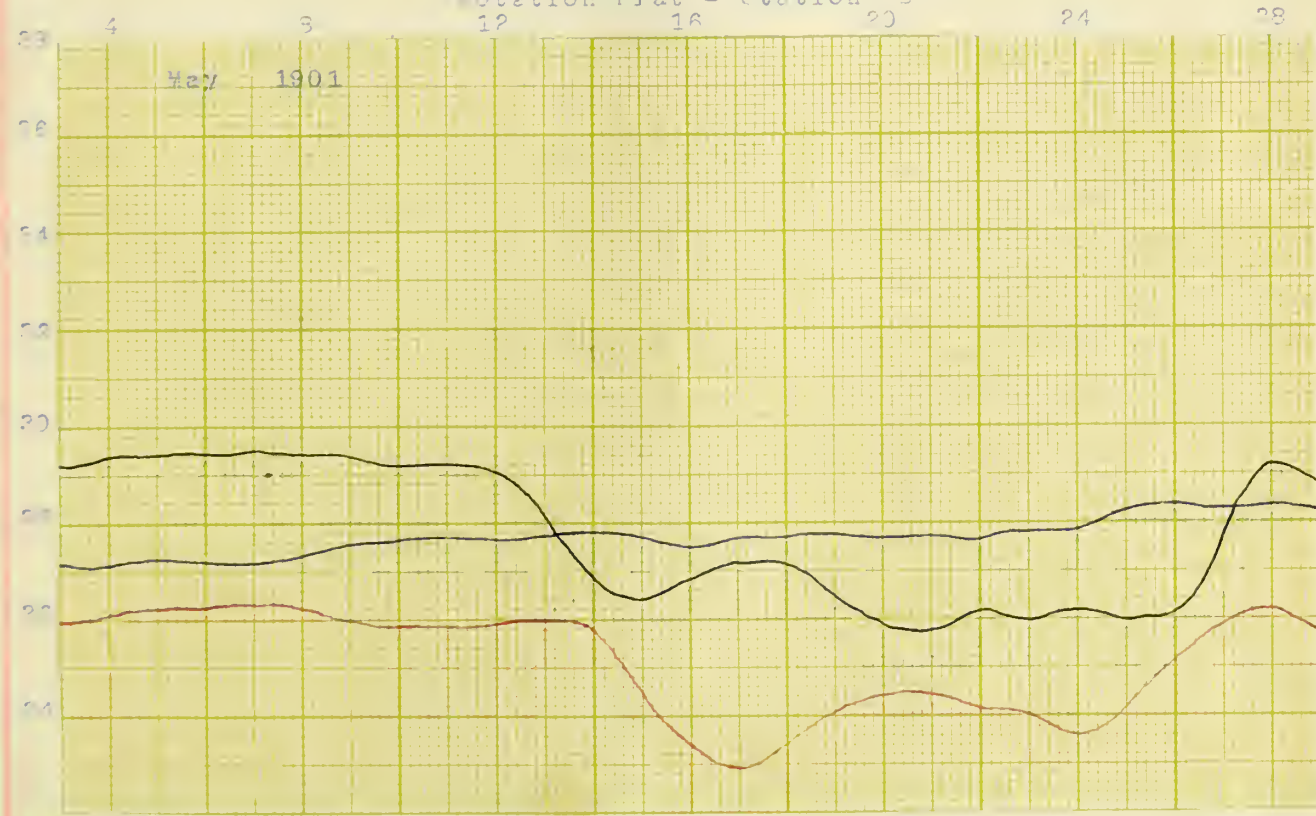
Rotation Plat - Station "A"



Point 1.00 .00.01.05 .22 .30.26

First foot - Black Second foot - Red Third foot - Blue  
\*\*\*\*\*

Rotation Plat - Station "B"

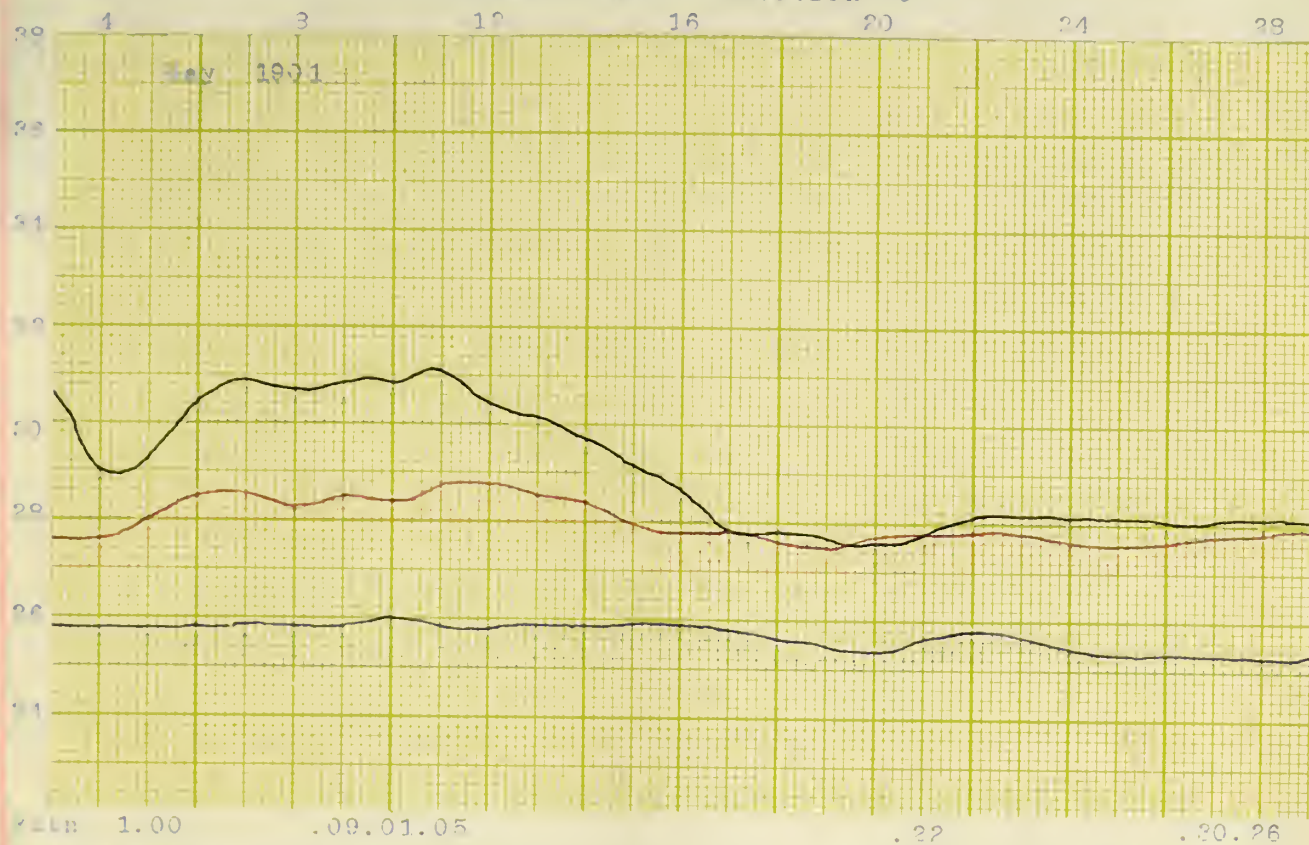


Point 1.00 .00.01.05 .22 .30.26





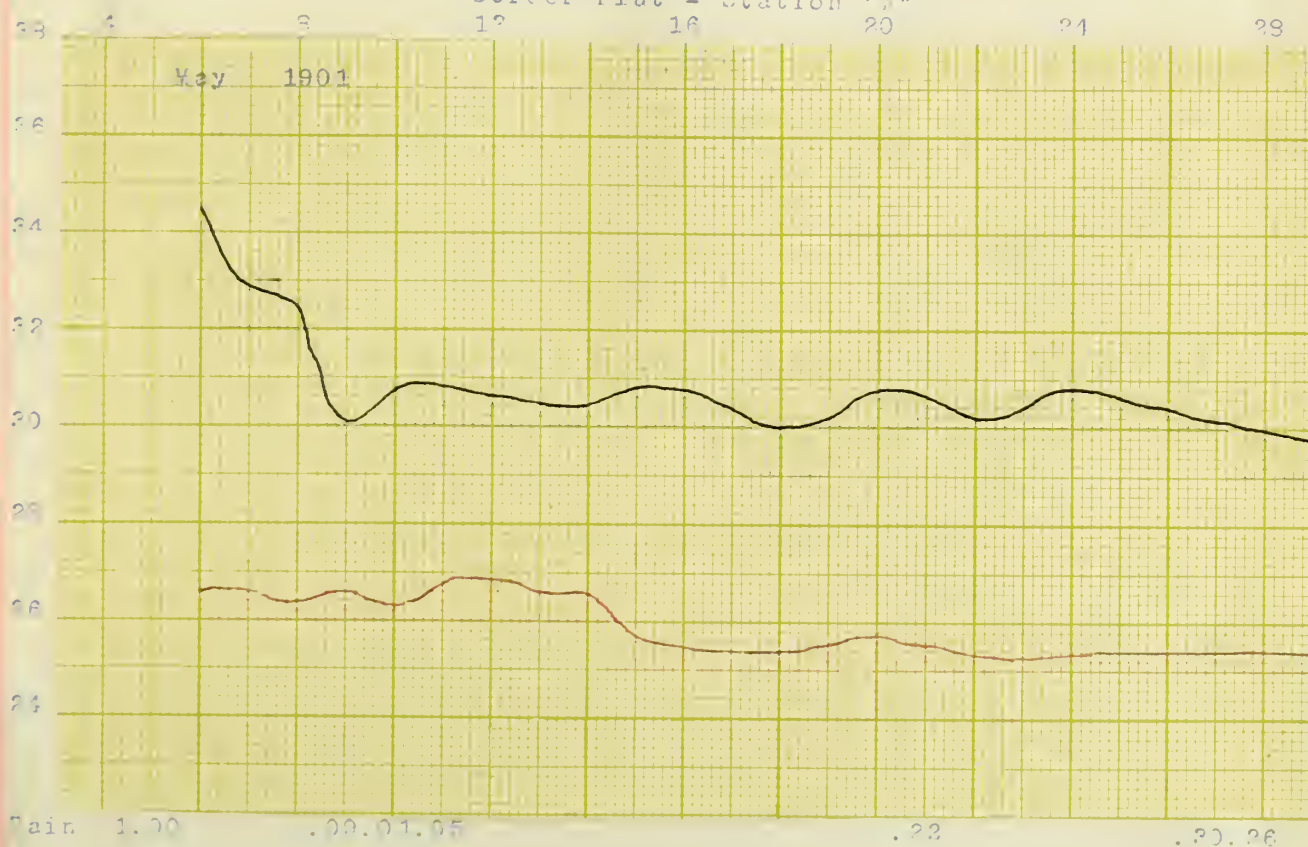
## Rotation Plat - Station "C"



First foot - Black Second foot - Red Third foot - Blue

\*\*\*\*\*

## Border Plat - Station "A"

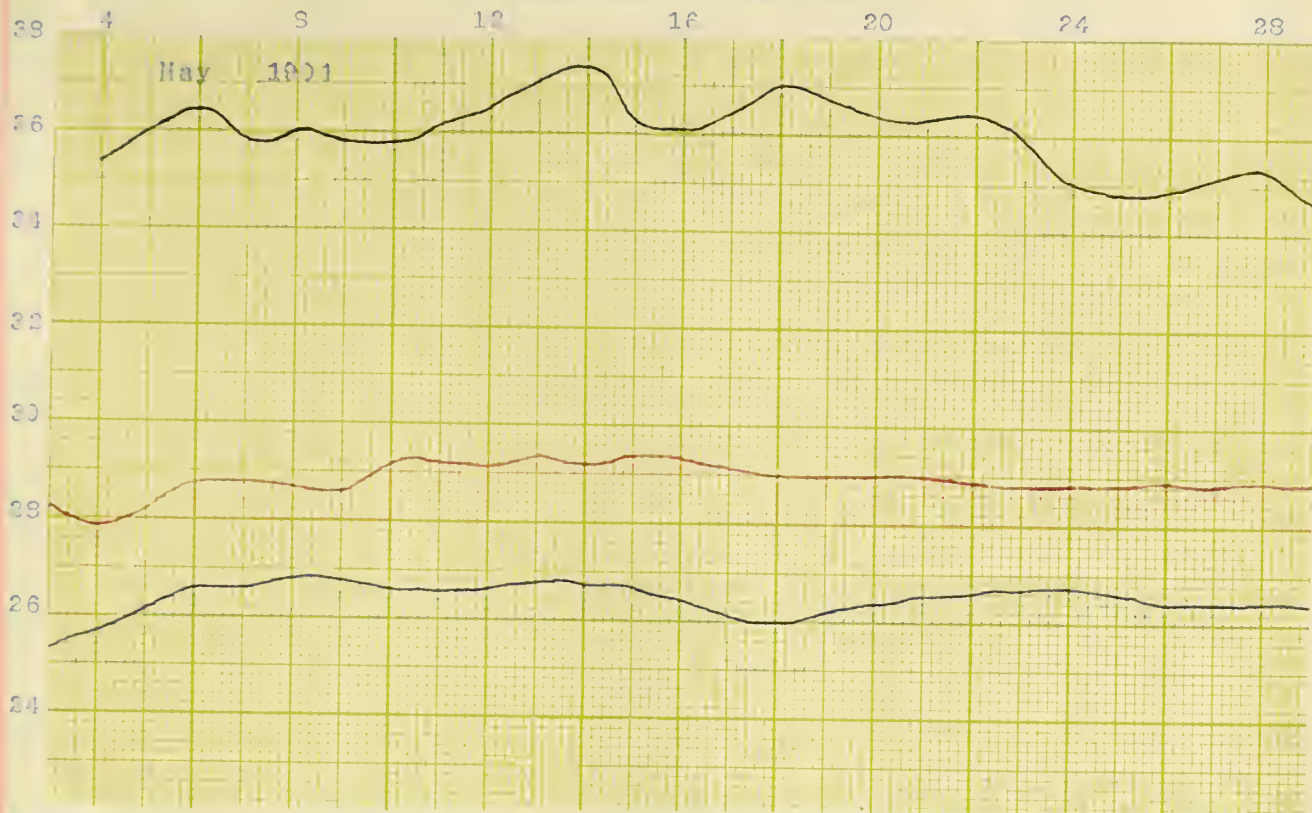


First foot - Black Second foot - Red Third foot - Blue





# Border Plat - Station "B"

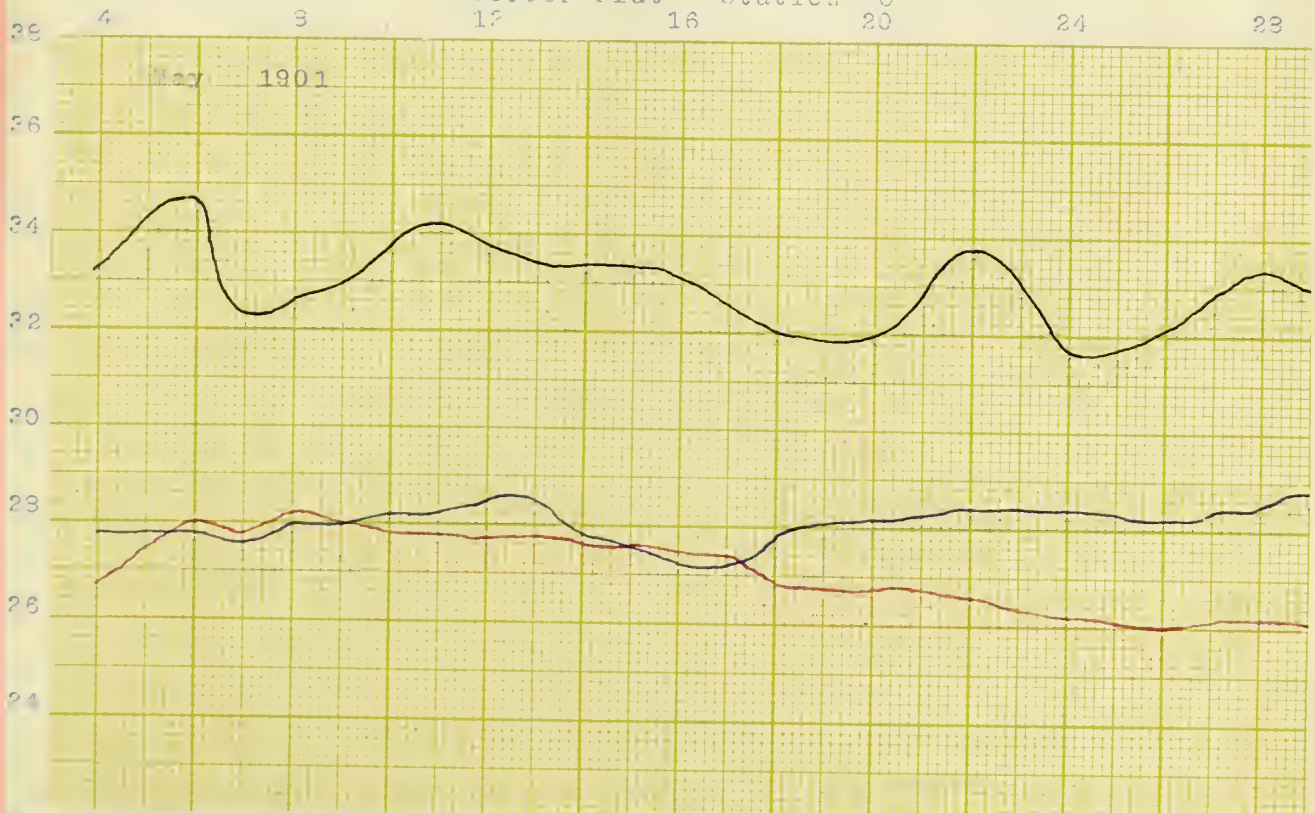


Rain 1.00 .09.01.05 .22 .30.26

First foot - Black Second foot - Red Third foot - Blue

\*\*\*\*\*

# Border Plat - Station "C"



Rain 1.00 .09.01.05 .22 .30.26



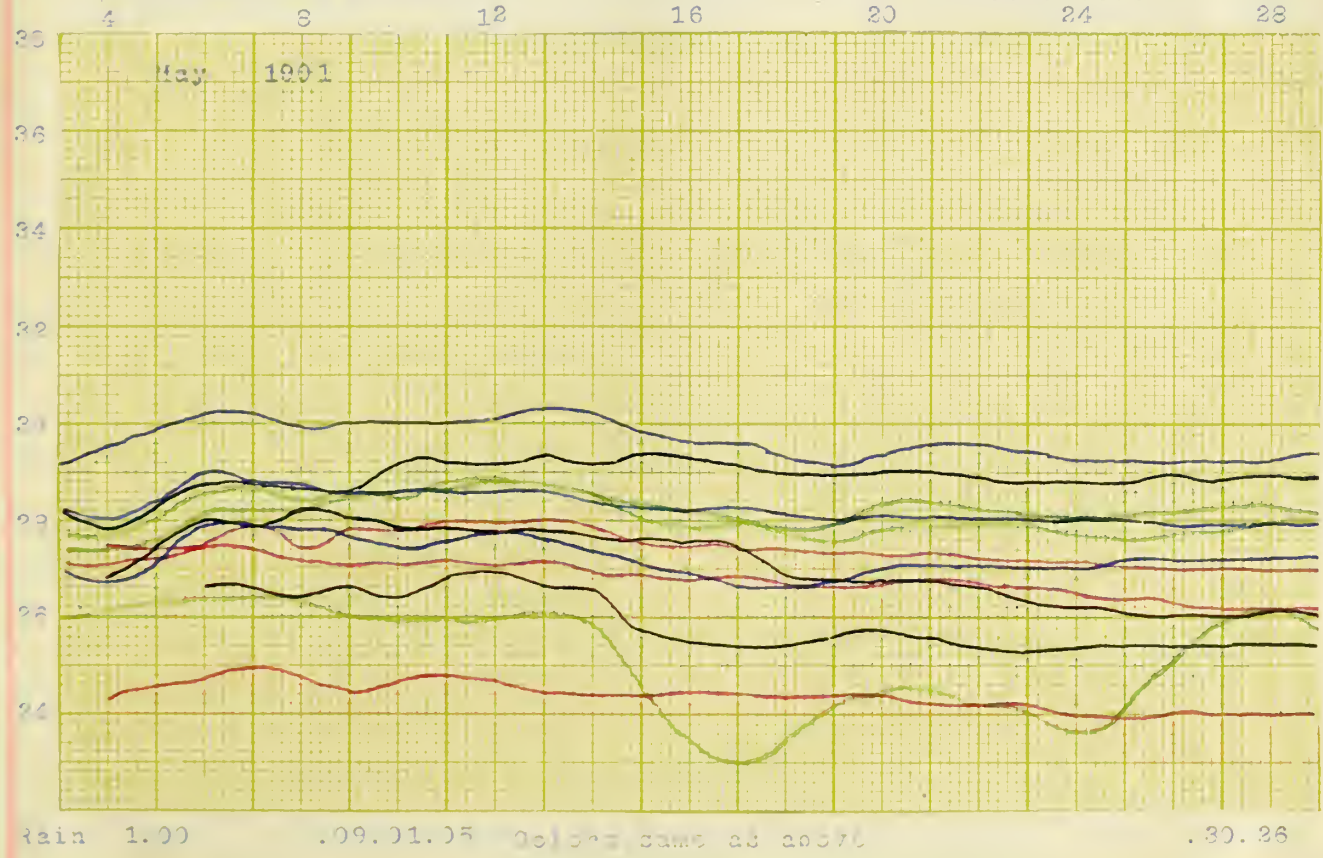


# Comparative moisture in the different plats - First foot



Border - Black Corn - Red Corn and Oats - Blue Rotation - Green

## \*\*\*\*\* Comparative moisture in the different plats - Second foot

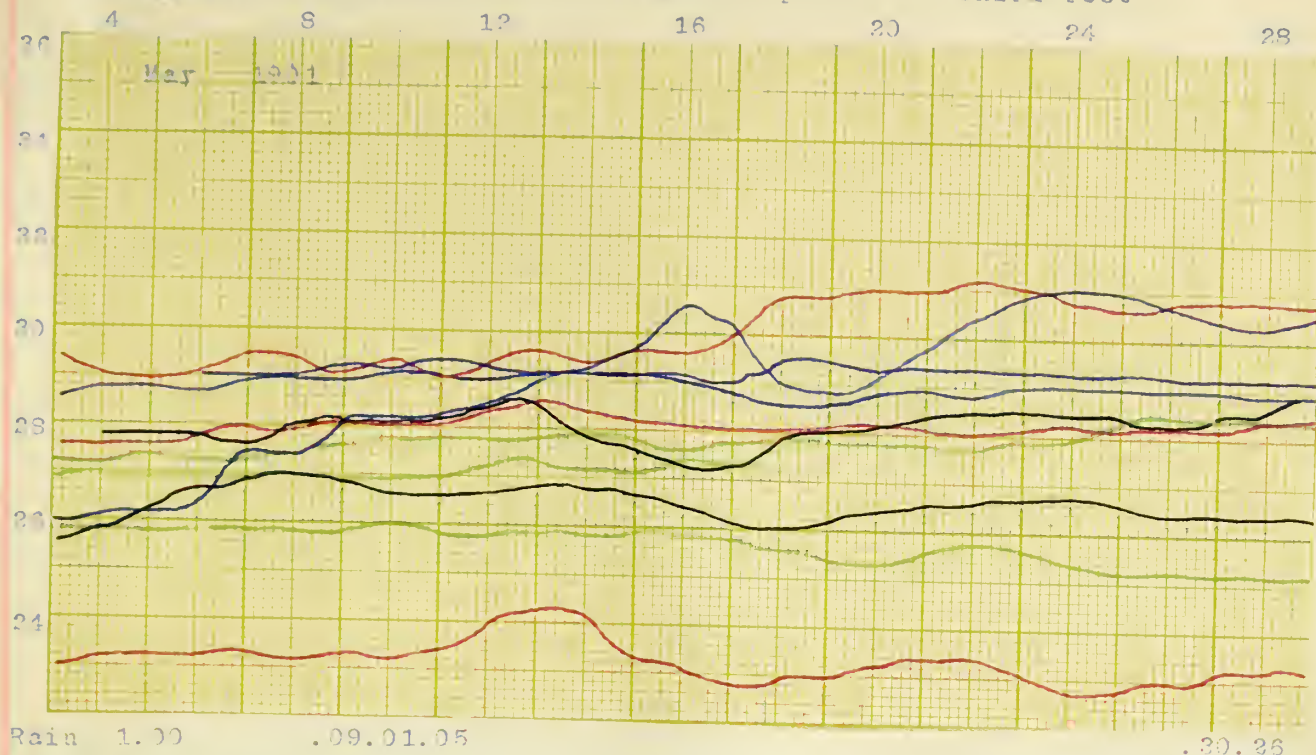


Border - Black Corn - Red Corn and Oats - Blue Rotation - Green





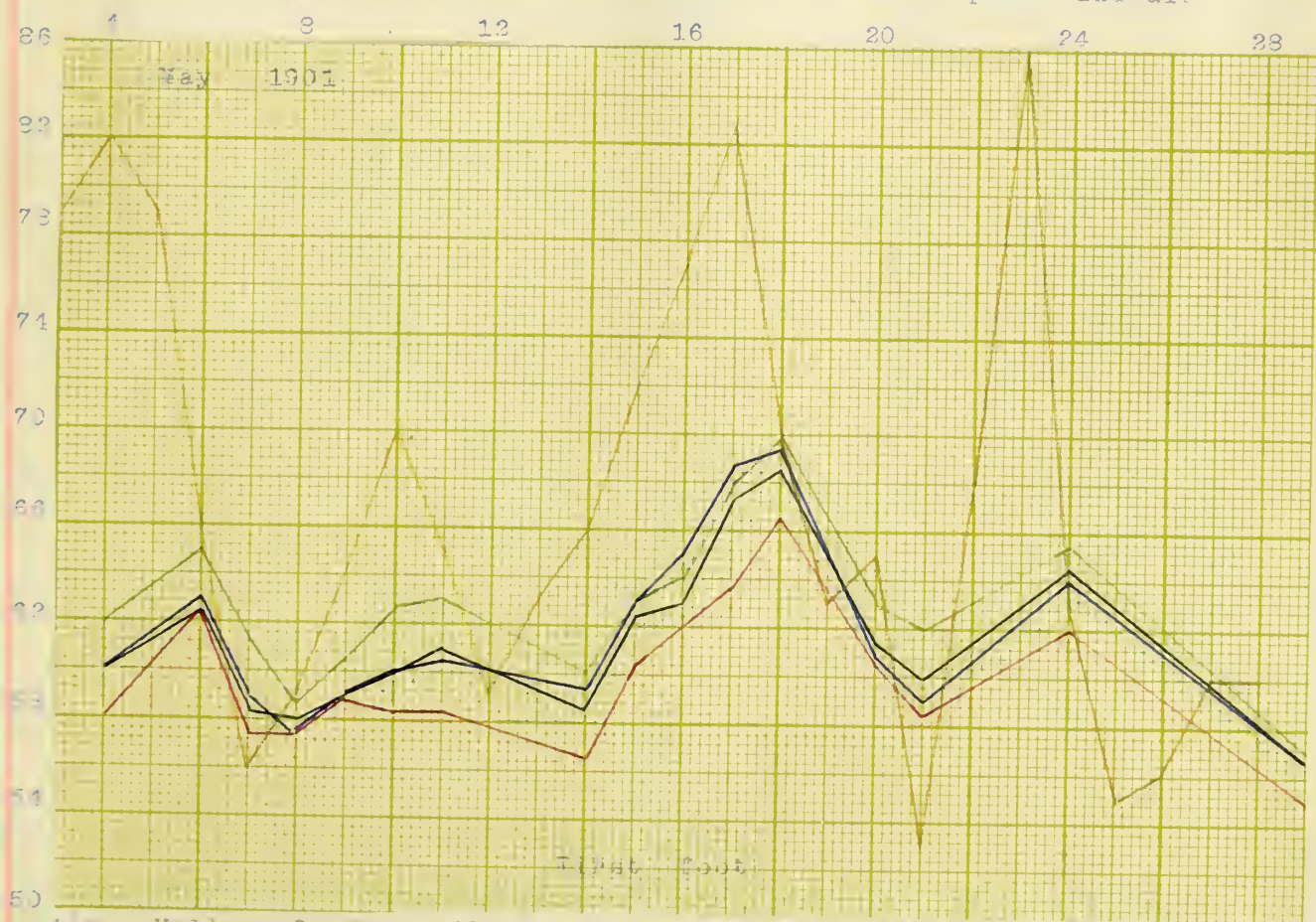
# Comparative moisture in the different plats - Third foot



Border - Black Corn - Red Corn and Oats - Blue Rotation - Green

\*\*\*\*\*

## Comparative temperature in the different plats and air

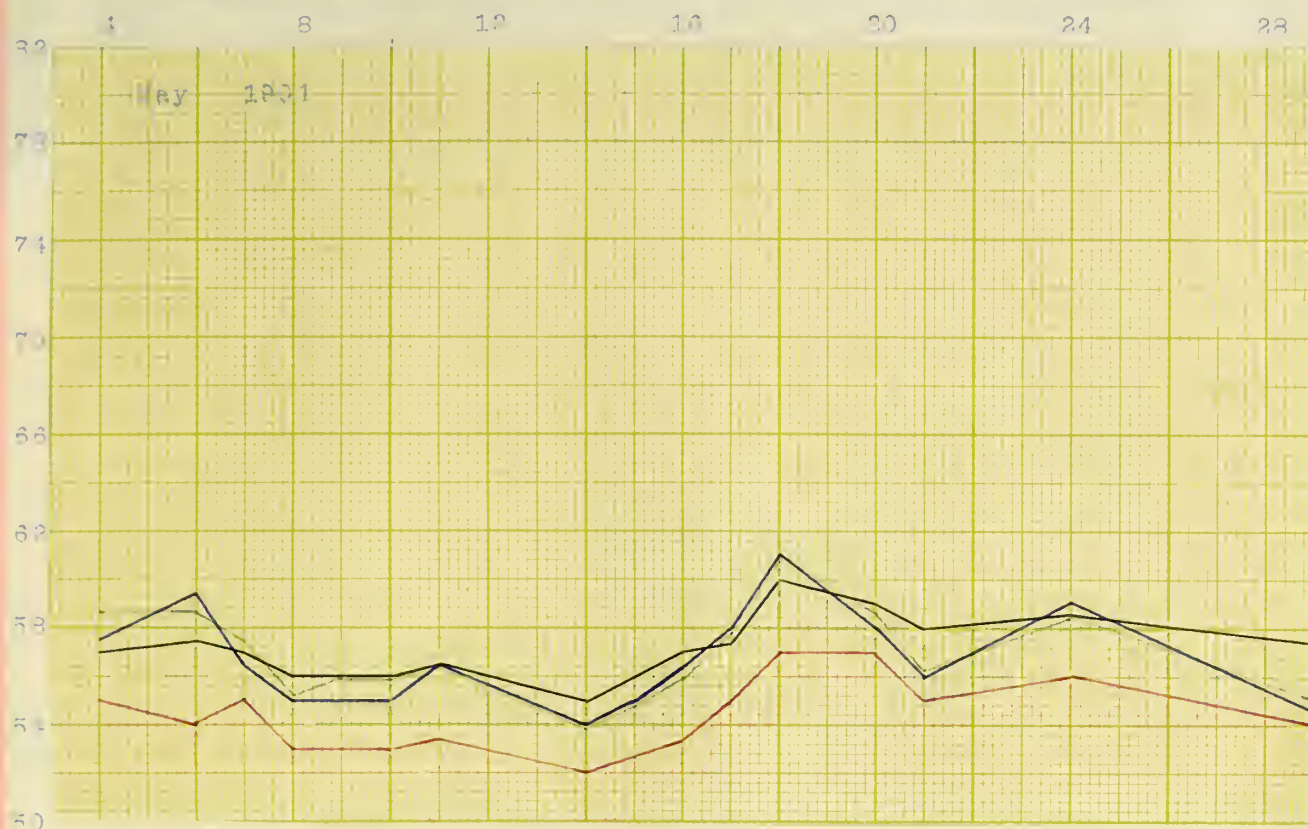


Air - Yellow Border - Black Corn - Red Corn and Oats - Blue Rotation - Green





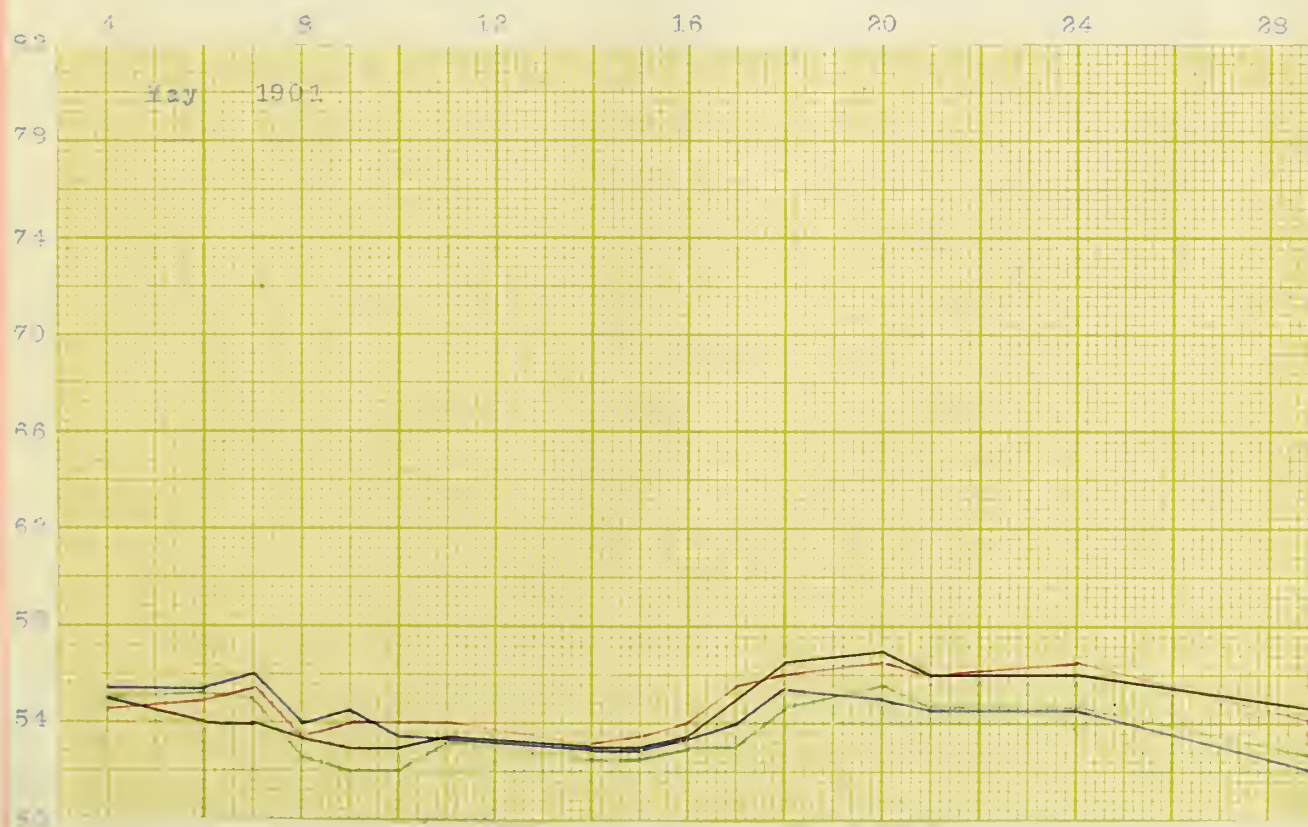
## Comparative temperature in the different plots - Second foot



Sorghum - Black    Corn - Red    Corn and Oats - Blue    Rotation - Green

\*\*\*\*\*

## Comparative temperature in the different plots - Third foot



Colors same as above



TABLE "A"

Day	Average Moisture of Soils												Rain Fall	Humidity of Air	Temperature of Air
	May 1901														
	Corn Org. Mat. 6.62			Corn & Oats Org. Mat. 7.66			Rotation Org. Mat. 7.75			Border Org. Mat. 9.772					
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd			
3	24.4	26.2	26.3	25.2	23.1	27.0	28.4	27.0	26.0	23.2	27.4	26.5		79	73
4	23.4	26.2	26.6	25.4	23.4	27.9	23.2	27.0	26.6	24.3	27.3	26.6		80	82
5	25.4	26.3	26.6	26.2	23.3	27.9	23.6	27.3	26.6	35.2	27.6	26.9	1.00	33	73
6	27.6	26.4	26.6	28.4	23.0	23.0	29.6	27.7	26.6	25.2	27.3	27.2		33	66
7	26.9	26.7	27.2	27.9	23.9	28.5	29.6	27.3	26.6	33.6	27.7	27.1		94	56
8	26.8	26.4	26.3	27.3	25.3	28.4	29.5	27.6	26.6	33.7	27.8	27.4		92	59
9	27.1	26.5	26.3	28.0	23.3	23.7	23.6	27.7	26.5	32.9	27.7	27.4	0.09	91	64
10	27.1	26.5	26.6	28.2	23.3	23.3	23.5	27.6	26.3	23.5	27.7	27.4	0.01	37	70
11	27.4	26.5	26.6	28.2	23.3	20.1	20.3	27.3	26.3	33.7	27.9	27.4	0.05	33	65
12	27.1	26.6	27.2	28.0	23.9	29.0	29.5	27.9	26.6	33.7	27.9	27.4		77	59
13	26.4	26.5	27.5	27.9	23.0	29.0	29.0	27.3	26.9	32.7	27.9	27.7		81	63
14	26.3	26.4	27.5	27.9	23.6	29.2	23.1	27.6	26.9	33.5	27.6	27.3		80	66
15	25.9	26.2	27.5	27.9	23.4	29.3	27.3	26.9	26.9	33.4	27.5	27.7		73	72
16	25.2	26.2	27.5	27.3	23.3	20.6	27.7	26.4	26.9	33.0	27.5	27.7		70	77
17	26.4	26.2	26.9	27.3	23.1	29.3	27.3	26.2	26.9	31.5	26.2	26.7		70	83
18	24.3	26.2	26.9	26.4	27.9	23.9	27.1	26.2	26.3	23.0	27.4	26.5		74	70
19	24.0	26.1	27.2	26.2	27.9	29.0	26.7	26.4	26.5	23.0	27.4	26.6		70	63
20	24.1	26.2	27.5	26.0	23.1	23.1	26.4	26.3	26.5	32.4	27.5	26.6		32	65
21	24.0	26.1	27.5	26.5	23.1	29.2	26.3	26.3	26.0	23.7	27.5	26.6	0.22	38	52
22	25.9	26.1	27.5	27.4	23.1	29.5	26.9	26.7	26.7	23.5	23.2	26.6		32	63
23	26.7	26.0	27.4	27.4	23.1	22.7	26.7	26.6	26.7	32.3	23.2	26.5		73	84
24	27.5	25.3	27.2	27.3	23.1	20.0	26.8	26.4	26.5	22.5	23.2	26.5		87	63
25	26.0	25.3	27.2	27.2	23.1	29.3	26.3	26.6	26.3	32.5	23.2	26.5		80	55
26	26.1	25.9	27.2	27.3	23.1	29.3	26.3	27.0	26.3	32.6	23.2	26.5		85	56
27	26.1	25.9	27.3	27.3	23.1	29.7	27.2	27.3	26.9	32.9	23.0	26.5	0.30	33	60
28	26.0	25.7	27.4	27.4	23.1	29.3	27.9	27.4	26.3	22.3	27.7	26.3	0.26	35	60
29	25.6	25.7	27.4	26.4	23.1	29.4	27.3	27.2	26.9	32.4	27.3	26.2		81	65

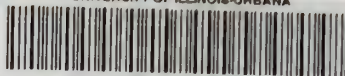
Humidity and Temperature at 2 P. M.  
Moisture readings from 3 to 5 P. M.







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